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PROJECTION-TYPE DISPLAY DEVICE
[Toei Gata Disupurei Sochi]

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Specification /1[1]

Title of the Invention: PROJECTION-TYPE DISPLAY DEVICE

Claim

A projection-type display device with the following characteristics: In a projection-type display device which uses a light valve, a first S polarization component and a first P polarization component are obtained by feeding the light obtained from a light source into a polarization beam splitter, whereas the aforementioned first S polarization component or first P polarization component is converted into a second S polarization component or second P polarization component by using a $\lambda/2$ optical phase wedge, whereas the synthesized beam of the aforementioned first and second S polarization components or the synthesized beam of the aforementioned first and second P polarization components is utilized as an illumination beam for the aforementioned light valve.

Detailed explanation of the invention

(Industrial application fields)

The present invention concerns a projection-type display device which uses a light valve.

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[1] Numbers in the margin indicate pagination in the foreign text.

(Prior art)

A device which uses a line light valve [array] has been proposed as a projection-type display device, as Figure 6 indicates.

In the same figure, (1) is a light source which possesses the light emission unit (2) and the reflector (3). A xenon arc lamp may, for example, be used as the light emission unit (2), whereas one which reflects visible light and transmits heat rays is employed as the reflector (3).

The light emitted from the light source (1) s transmitted through the heat ray reflection panel (4), which reflects heat rays but transmits visible light, and then fed into the condenser lens (5), as a result of which it becomes converted into a parallel luminous flux. The light obtained from this condenser lens (5) is transmitted through the aperture panel (6) and then fed into the polarization beam splitter (7), which constitutes a polarization element, as a result of which a polarization which possesses a certain polarization plane, namely the P [amended] polarization L_P [amended], alone becomes obtained as a transmission component. The polarization obtained from this polarization beam splitter (7) becomes fed into the fishcake (kamaboko)-shaped lens (8), and after it has been thereby converted into a luminous flux which possesses a narrow band-shaped polarization cross section which is extended along horizontal directions, it is fed into the line light valve [array] (10), which is being supported by the transparent support panel (9), as an illumination beam. This line light valve [array] (10) may, for

example, be constituted by a PLZT electrooptic ceramic material, and it is formed by 512 light valves, whereas the polarization plane of the luminous flux with a cross-sectional shape corresponding to a flat narrow band, which has become fed from the fishcake-shaped lens (8), becomes rotated by a certain angle in relation to a video signal [amended] by each light valve member.

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After its polarization plane has become rotated by a certain angle by said line light valve [array] (10), the light becomes transmitted through the contraction lens (11), and after its optical path has been altered by the mobile mirror (12), which engages in a polarization scan action along the vertical directions, it is transmitted through the field lens (13), and after it has then been fed into the polarization beam splitter (14), which constitutes a beam detection element, its portion corresponding to the rotation angle of the polarization plane at the aforementioned line light valve [array] (10) alone becomes transmitted.

The light obtained from this polarization beam splitter (14) becomes projected on a screen (not shown in the figure) by the projection lens (15).

In Figure 6, furthermore, (16) is a control circuit unit, and the video signal S_V becomes fed into its input terminal (16a). The 512 light valves of the line light valve [array] (10), furthermore, are sequentially driven by the sample signals of 512 points within each horizontal period of the video signal S_V, and a control is rendered in synchrony with the horizontal period of the video signal S_V in

such a way that the polarization plane will become rotated by angles corresponding to the signal contents by the respective light valve members. The mirror drive unit (17), furthermore, is controlled in such a way that the mobile mirror (12) will engage in a polarization scan action in synchrony with the vertical period of the video signal S_V.

An image expressed by the video signal S_V becomes obtained on the screen of this display device characterized by the foregoing constitution shown in Figure 6.

(Problems to be solved by the invention)

As far as this display device shown in Figure 6 is concerned, the only portion of the light emitted from the light source (1) that becomes utilized as the luminous flux is the P [amended] polarization component L_P [amended], which has been obtained as a result of transmission through the polarization beam splitter (7), whereas another portion of the light emitted from the light source (1), namely the S [amended] polarization component L_S [amended], which possesses a polarization plane which perpendicularly intersects the P [amended] polarization component L_P [amended], becomes reflected by 45° [amended] by the polarization beam splitter (7) and cannot be utilized as an illumination beam. This display device shown in Figure 6 is therefore problematic in that the utilization efficiency of the light emitted from the light source (1) is as low as 50% or below.

The present invention therefore attempts to improve the utilization efficiency of the light emitted from the light source.

(Mechanism for solving the problems)

The aforementioned problem is solved in the present invention by converting the polarization plane of either the S polarization component L_S or P polarization component L_P obtained from a polarization beam splitter into the polarization plane of the other by using a $\lambda/2$ optical phase wedge, and their synthesized beam is utilized as an illumination beam for a light valve.

(Functions)

Both the S polarization component L_S and P polarization component L_P obtained from the polarization beam splitter become utilized as illumination beams, based on which the utilization efficiency of the light emitted from the light source can be improved.

(Application examples)

In the following, an application example of the present invention will be explained with reference to Figure 1. The present example instantiates an application embodiment of a display device which uses the line light valve [array] (10) shown in Figure 6. In this Figure 1, components corresponding to their counterparts in Figure 6 are designated to bear identical notations for dispensing with their detailed explanations.

Figure 1 is a diagram which shows a view along the vertical

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In the same figure, the total reflection prism (18) is configured on the side where the S [amended] polarization component of the polarization beam splitter (7) becomes obtained as a result of reflection, whereas the S [amended] polarization component L_S [amended] becomes reflected perpendicularly by this total reflection prism (18), transmitted through the polarization beam splitter (7), and then emitted along a direction identical to that of the obtained P [amended] polarization component L_P [amended]. On the exit side of the total reflection prism (18), furthermore, is configured the $\lambda/2$ optical phase panel (19), whereas the polarization plane of the S [amended] polarization component L_S [amended] emitted from the total reflection prism (18) becomes rotated by 90° by this $\lambda/2$ optical phase panel (19), and it is thus converted into the P [amended] polarization component L_P^* [amended]. The wedgy lenses (prisms) (20) and (21) for changing optical paths, furthermore, are configured on the respective frontal planes of the polarization beam splitter (7) and the $\lambda/2$ optical phase panel (19), whereas the respective optical paths of the P [amended] polarization component L_P [amended] obtained as a result of transmission through the polarization beam splitter (7) and the P [amended] polarization component L_P^* [amended] obtained as a result of conversion by the $\lambda/2$ optical phase panel (19) become changed, and they are synthesized in such a way that they will mutually coincide at a certain position P_0.

The line light valve [array] (10), furthermore, is configured at a stage anterior to the specified position P_0, and furthermore, the fishcake-shaped lens (8) is configured at a stage anterior to this

line light valve [array] (10). The beam synthesized from the P [amended] polarization components L_P [amended] and L_P^* [amended], furthermore, becomes converted into a luminous flux with a cross-sectional shape corresponding to a flat narrow band which extends along the horizontal direction by the fishcake-shaped lens (8) and then fed into the line light valve [array] (10) as an illumination beam.

The control circuit unit (16) of the present example may, furthermore, be characterized by the constitution shown in Figure 2, although it is not directly related to the present invention. In this Figure 2, components identical to their counterparts in Figure 1 are designated to bear identical notations.

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In Figure 2, the video signal S_V which has become fed into the input terminal (16a) is then fed into the synchronous separation circuit (23) via the video signal amplification circuit (22). The vertical synchronous signal P_v obtained from this synchronous separation circuit (23) becomes fed into the polarization control circuit (24), and the mobile mirror (12) (see Figure 6) comes to engage in a polarization scan action in synchrony with the vertical period of the video signal S_V while the mirror drive unit (17) is being controlled by this polarization control circuit (24).

The horizontal synchronous signal P_H obtained from the synchronous separation circuit (23), furthermore, becomes fed into the oscillator (25) as a standard signal, and after a frequency signal of 1024 f_H (f_H is the horizontal frequency) has, for example, been obtained from

this oscillator (25), it becomes fed into the sample pulse generator (26). 64 output terminals O_1, O_2, ... O_{64}, furthermore, are configured on the sample pulse generator (26), whereas the final timing sample pulses SP_1, SP_2, ... SP_{64} (graphically shown in B of Figure 3), which have been obtained by dividing a single horizontal period (1H) into 64 phases, are obtained from the respective output terminals O_1, O_2, ... O_{64}. Incidentally, A of Figure 3 signifies the horizontal synchronous signal P_H.

In Figure 2, furthermore, the video signal S_V obtained from the synchronous separation circuit (23) becomes fed into the delay line (29) via the γ calibration circuit (27) and the delay circuit (28) for the purpose of time adjustment. Eight taps P_1, P_2, ... P_8 are configured on this delay line (29), where an updated version of the synchronous signal is obtained at the tap P_8, whereas signals the phases of which are sequentially anterior to it by 1/512 horizontal periods (1/512 H) each are obtained at the taps P_7, P_6, ... P_1. These taps P_1, P_2, ... P_8 are connected respectively to the amplifiers (30_1), (30_2), ... (30_8), whereas the signals obtained from the amplifiers (30_1), (30_2), ... (30_8) become fed into the respective signal electrodes of the light valves l_1, l_2, ... l_8 of the line light valve [array] (10), which, as is shown in Figure 4, is constituted by 512 light valves l_1, l_2, ... l_{512}, via the respective drain-source portions of the field effect transistors (hereafter referred to as "FETs") T_1, T_2, ... T_8. The respective signals obtained from the amplifiers (30_1), (30_2), ... (30_8), furthermore, become fed into the respective signal electrodes of the light valves l_9, l_{10}, ... l_{16} via

the respective drain-source portions of the FETs T_9, T_{10}, ... T_{16}, whereas the signals subsequently obtained from the amplifiers (30_1), (30_2), ... (30_8) become sequentially fed into the respective signal electrodes of the next eight light valves of the line light valve [array] (10) in similar fashions.

The sample pulse SP_1 obtained at the output terminal O_1 of the sample pulse generator (26), furthermore, become fed into the respective gates of the FETs T_1, T_2, ..., T_8, whereas these FETs T_1, T_2, ..., T_8 are switched ON by the timing of said sample pulse SP_1. The sample pulse SP_2 obtained at the output terminal O_2, furthermore, becomes fed into the respective bases of the FETs T_9, T_{10}, ... T_{16}, whereas these FETs T_9, T_{10}, ... T_{16} become turned ON by the timing of said sample pulse SP_2, and thus, the sample pulses SP_3, SP_4, ... SP_{64} obtained respectively at the output terminals O_3, O_4, ... O_{64} likewise become fed into the respective gates of the next 8 unit FETs, and said 8 unit FETs are turned ON by the timings of the respective sample pulses SP_3, SP_4, ... SP_{64}.

Of the respective horizontal period signal components of the video signal S_V, therefore, eight sample signals S_1, S_2, ..., S_8 included in the 1/64 horizontal period (1/64 H) ranging from the horizontal synchronous signal P_H to the sample pulse SP_1 become fed into the respective signal electrodes of the light valves l_1, l_2, ..., l_8 of the line light valve [array] (10) via the respective FETs T_1, T_2, ..., T_8. Of the respective horizontal period signal components of the video signal S_V, furthermore, eight sample signals S_9, S_{10}, ..., S_{16} included in the 1/64 horizontal period ranging from the sample pulse

SP_1 to SP_2 become fed into the respective signal electrodes of the light valves l_9, l_{10}, ..., l_{16} of the line light valve [array] (10) via the respective FETs T_9, T_{10}, ..., T_{16}. Likewise, the sample signals S_{17}, S_{18}, ..., S_{512} become fed into the respective signal electrodes of the light valves l_{17}, l_{18}, ..., l_{512} of the line light valve [array] (10). The 512 light valves l_{17}, l_{18}, ..., l_{512} of the line light valve [array] (10) accordingly become driven by the respective signals S_1, S_2, ..., S_{512}.

In a case where the control circuit unit (16) is thus constituted, eight signals each become sampled in parallel into the respective signal electrodes of the light valves l_{17}, l_{18}, ..., l_{512} of the line light valve [array] (10), based on which the sampling frequency can be lowered in comparison with that of the sequential sampling format, and the number of the steps of the shift register of the sample pulse generator (26) constituted by such a shift register may, for example, be significantly reduced while the number of components and electricity consumption are being significantly minimized as well. The driving actions of the respective light valves l_1, l_2, ..., l_{512} of the line light valve [array] (10) by digital signals, furthermore, are easily enabled by sequentially feeding the digital signals [1,0] by using the taps P_1, P_2, ... P_8. /4

Based on the constitution of the present example shown in Figure 1, both the S polarization component L_S and P polarization component L_P obtained from the polarization beam splitter can be utilized as illumination beams for the line light valve [array] (10), based on which the utilization efficiency of the light emitted from the light

source (1) can be improved. In a case where the line light valve [array] (10) is configured at a stage anterior to the specified position P_0, as in the present example, furthermore, the illumination coverage of a line light valve [array] (10) with an extremely large length/width ratio is afforded by the interplay of the P [amended] polarization components L_P [amended] and L_P^* [amended], based on which the original illumination [beam] diameter can be minimized, and ones with minimal dimensions become usable for the polarization beam splitter (7), etc., which is beneficial in that an inexpensive constitution can be provided. In the case of the present example, furthermore, the P [amended] polarization components L_P [amended] and L_P^* [amended] constitute inner refraction conditions, and therefore, the field lens effect can be effectively conferred by designating the specified position P_0 at the incident pupil [sic: Presumably "incident beam"] center of the contraction lens (11) (see Figure 6) while the wedgy lenses (20) and (21) are being correspondingly designated.

Next, Figure 5 shows another application example of the present invention, where components corresponding to their counterparts in Figure 1 are designated to bear identical notations for dispensing with their detailed explanations.

In the example of Figure 5, the $\lambda/2$ optical phase panel (31) is configured at a stage anterior to the wedgy lenses (20) and (21), whereas the respective polarization planes of the P [amended] polarization L_P [amended] obtained as a result of transmission through the polarization beam splitter (7) and the P [amended]

polarization component L_P^* [amended] obtained as a result of conversion by the $\lambda/2$ optical phase panel (19) become rotated by 45°. The constitution is otherwise identical to that of the example shown in Figure 1.

In a case where the respective polarization planes of the P [amended] polarization components L_P [amended] and L_P^* [amended] are rotated by 45°, as in this example shown in Figure 5, their respective polarization planes come to form an angle of 45° in relation to the electric field impressed on each light valve of the line light valve [array] (10), based on which a maximal polarization sensitivity comes to be achieved by the line light valve [array] (10).

Incidentally, one of the transmission type through which light becomes transmitted has been shown as the line light valve [array] (10) of the application example discussed above, although one of the reflection type, which reflects the light emitted from the line light valve, is equally applicable. The use of the line light valve [array] (10) has, furthermore, been instantiated in the aforementioned application example, although the use of a two-dimensional light valve [array] is equally applicable. As far as the aforementioned application example is concerned, furthermore, the polarization plane of the S [amended] polarization component L_S [amended] obtained from the polarization beam splitter (7) is rotated by 90° in the context of obtaining a synthesized beam of the P [amended] polarization components. Conversely, furthermore, it is also possible to rotate the polarization plane of the P [amended] polarization component L_P [amended] obtained from the polarization

beam splitter (7) by 90° and to use it in the context of obtaining a synthesized beam of the S [amended] polarization components. A mirror may, furthermore, be employed in place of the total reflection prism (18) in the aforementioned application example.

(Effects of the invention)

As has been mentioned above, as far as the present invention is concerned, both the S polarization component L_S and P polarization component L_P obtained from a polarization beam splitter are utilized as illumination beams for light valves, based on which the utilization efficiency of light emitted from a light source is improved. In a case where a light source identical to its counterpart of the prior art is used, therefore, an image of a higher luminosity can be projected on the screen.

Brief explanation of the figures

Figure 1 is a constitutional diagram which shows an application example of the present invention, whereas Figure 2 is a constitutional diagram which concretely instantiates a control circuit unit, whereas Figures 3 and 4 are diagrams each provided for explaining it, whereas Figure 5 is a constitutional diagram which shows another application example of the present invention, whereas Figure 6 is a constitutional diagram which shows an application example of the prior art.

(1) is a light source, whereas (7) is a polarization beam splitter, whereas (8) is a fishcake-shaped lens, whereas (10) is a line light

valve [array], whereas (18) is a total reflection prism, whereas (19) and (31) are each λ/2 optical phase panels, whereas (20) and (21) are each wedgy lenses.

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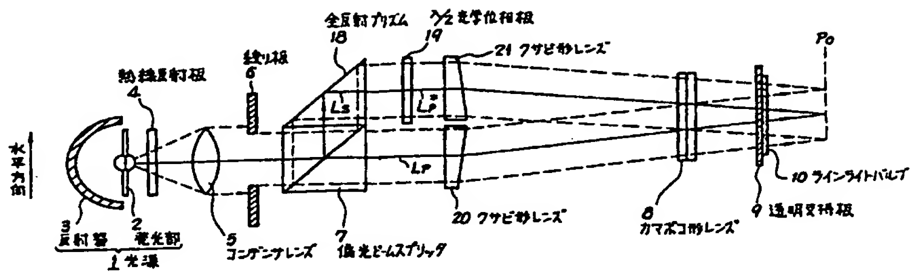
Figure 1 [amended]

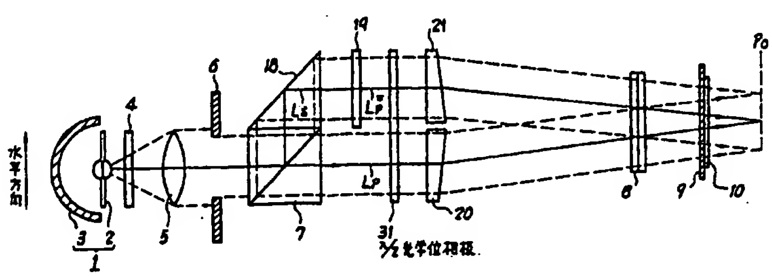
第 1 図



[(H): Horizontal direction; (1): Light source; (2): Light emission unit; (3): Reflector; (4): Heat ray reflection panel; (5): Condenser lens; (6): Aperture panel; (7): Polarization beam splitter; (8): Fishcake-shaped lens; (9): Transparent support panel; (10): Line light valve [array]; (18): Total reflection prism; (19): Λ/2 optical phase panel; (21): Wedgy lens]

Figure 5 [amended]

第 5 図



[(H): Horizontal direction; (31): $\Lambda/2$ optical phase panel]

Figure 2

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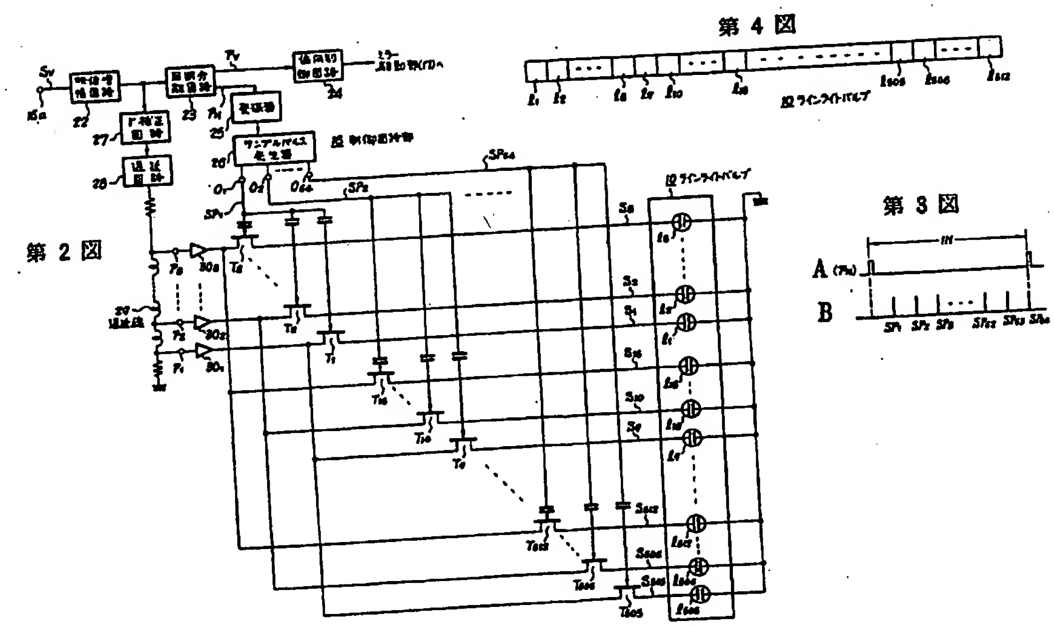

[(T): To mirror drive unit (17); (10): Line light valve [array]; (16): Control circuit unit; (22): Video signal amplification circuit; (23): Synchronous separation circuit; (24): Polarization control circuit; (25): Oscillator; (26): Sample pulse generator; (27): γ calibration circuit; (28): Delay circuit; (29): Delay line]

Figure 4

[(10): Line light valve [array]]

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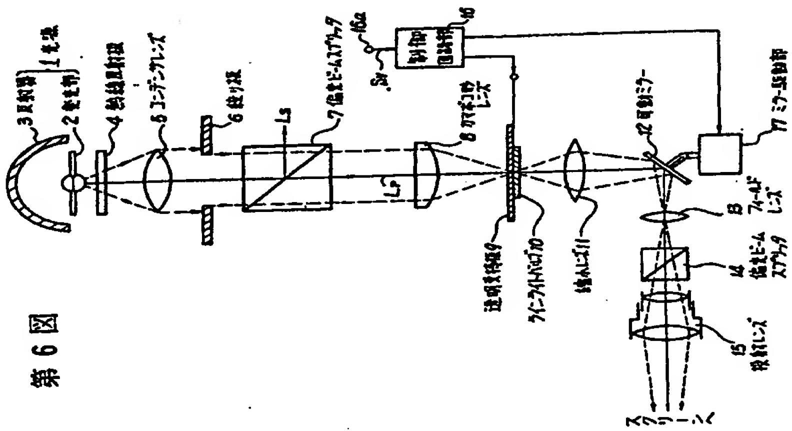
Figure 6 [amended]



第6図

[(T): To screen; (1): Light source; (2): Light emission unit; (3): Reflector; (4): Heat ray reflection panel; (5): Condenser lens; (6): Aperture panel; (7): Polarization beam splitter; (8): Fishcake-shaped lens; (9): Transparent support panel; (10): Line light valve [array]; (11): Contraction lens; (12): Mobile mirror; (13): Field lens; (14): Polarization beam splitter; (15): Projection lens; (16): Control circuit unit; (17): Mirror drive unit]